

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	East- ern stand- ard time	Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
			Diff. in longi- tude	Longi- tude	Lat- itude	Spot or group	Total for each day		
1938	h m		°	°	°				
Oct. 26...	12 27	6166	-8.0	102.5	-11.0	170	-----	20	U. S. Naval.
		6160	-3.0	107.5	-15.0	388	-----	28	
		6155	+9.5	120.0	+13.0	73	-----	9	
		6156	+13.0	123.5	+25.0	194	-----	9	
		6154	+30.0	140.5	-11.0	97	-----	2	
		6158	+61.0	173.5	+11.5	12	1,273	1	
Oct. 27...	11 14	6171	-73.0	25.0	+9.0	12	-----	2	Do.
		6168	-64.0	34.0	+26.0	133	-----	2	
		6164	-53.0	45.0	+15.0	182	-----	2	
		6167	-17.0	81.0	-31.0	24	-----	4	
		6163	+5.0	103.0	-25.0	48	-----	10	
		6166	+5.0	103.0	-11.0	242	-----	8	
		6165	+8.0	106.0	-19.0	12	-----	2	
		6160	+11.0	109.0	-15.0	388	-----	20	
		6155	+21.0	119.0	+12.0	48	-----	6	
		6156	+26.0	124.0	+25.0	315	-----	12	
		6154	+41.0	139.0	-11.0	73	1,477	3	
Oct. 28...	11 4	6175	-79.0	5.9	+18.0	36	-----	3	Mt. Wilson.
		6171	-60.0	24.9	+10.0	73	-----	13	
		6168	-50.0	34.9	+26.0	242	-----	20	
		6164	-40.5	44.4	+14.0	109	-----	2	
		6174	-22.0	62.9	-15.0	12	-----	5	
		6170	-6.5	78.4	-12.0	61	-----	12	
		6167	-6.0	78.9	-32.0	12	-----	2	
		6173	-4.0	80.9	+13.0	12	-----	2	
		6169	-2.0	82.9	+9.0	48	-----	13	
		6166	+10.0	103.9	-11.0	194	-----	16	
		6163	+30.0	104.9	-22.0	109	-----	12	
		6160	+25.0	109.9	-15.0	388	-----	40	
		6172	+27.0	111.9	-2.0	6	-----	1	
		6155	+35.0	119.9	+13.0	48	-----	6	
		6156	+39.0	123.9	+25.0	291	-----	18	
		6154	+56.0	140.9	-11.0	48	1,689	3	
Oct. 29...	14 21	6177	-78.0	351.9	+11.0	145	-----	2	U. S. Naval.
		6176	-73.0	356.9	-9.0	242	-----	4	
		6175	-63.0	6.9	+17.0	61	-----	3	
		6171	-45.0	24.9	+10.0	12	-----	1	
		6168	-37.0	32.9	+26.0	291	-----	23	
		6164	-26.5	43.4	+14.0	121	-----	1	
		6167	-9.5	79.4	-31.5	24	-----	2	
		6173	+10.0	79.9	+15.0	97	-----	6	
		6169	+12.0	81.9	+9.5	61	-----	16	
		6163	+34.0	103.9	-22.5	194	-----	10	
		6166	+34.0	103.9	-11.0	145	-----	15	
		6160	+41.0	110.9	-14.0	388	-----	1	
		6172	+41.5	111.4	-3.0	24	-----	6	
		6156	+51.0	120.9	+27.0	121	-----	1	
		6154	+70.0	139.9	-11.0	6	1,932	1	
Oct. 30...	11 33	6177	-65.0	353.2	+11.0	145	-----	4	Do.
		6176	-61.0	357.2	-8.0	218	-----	4	
		6175	-53.0	5.2	+19.0	121	-----	8	
		6171	-35.0	23.2	+10.0	12	-----	2	
		6168	-25.0	33.2	+26.0	291	-----	16	
		6164	-15.0	43.2	+15.0	121	-----	4	
		6179	+6.0	64.2	+16.0	6	-----	1	
		6167	+23.0	81.2	-30.5	12	-----	1	
		6173	+23.0	81.2	+16.0	97	-----	7	
		6169	+24.0	82.2	+9.5	24	-----	4	
		6178	+35.0	63.2	+17.0	6	-----	1	
		6163	+45.0	103.2	-23.0	315	-----	23	
		6166	+49.0	107.2	-11.0	97	-----	4	
		6160	+53.0	111.2	-13.5	485	-----	28	
		6172	+53.0	111.2	-3.0	24	-----	4	
		6156	+64.0	122.2	+27.0	194	2,168	2	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	East- ern stand- ard time	Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
			Diff. in longi- tude	Longi- tude	Lat- itude	Spot or group	Total for each day		
1938	h m		°	°	°				
Oct. 31...	11 12	6180	-64.0	341.2	-4.5	36	-----	3	U. S. Naval.
		6177	-52.0	353.2	+11.0	97	-----	3	
		6176	-50.0	355.2	-9.0	218	-----	10	
		6175	-39.0	6.2	+18.0	85	-----	4	
		6181	-24.0	21.2	-12.0	6	-----	4	
		(*)	-10.0	29.2	+14.0	6	-----	1	
		6168	-11.0	34.2	+24.5	315	-----	39	
		6164	-1.0	44.2	+14.5	121	-----	2	
		6173	+37.0	82.2	+15.0	121	-----	3	
		6163	+38.0	103.2	-23.0	315	-----	14	
		6166	+63.0	108.2	-11.0	48	-----	1	
		6160	+65.0	110.2	-13.0	388	-----	12	
		6156	+78.0	123.2	+27.0	194	1,950	3	

Mean daily area for 30 days—1,951.

*Not numbered.

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR
OCTOBER 1938

[Dependent alone on observations at Zurich, Switzerland]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich, Switzerland]

October 1938	Relative numbers	October 1938	Relative numbers	October 1938	Relative numbers
1		11		21	55
2		12	134	22	46
3	94	13	121	23	EC 61
4	Mac	14	122	24	a
5	Macd 15	15	103	25	aa 91
6	Mc 102	16	78	26	ad 104
7	92	17	Mc 71	27	
8	102	18	d 31	28	Mc
9	d 143	19	20	29	ad 148
10	152	20	Ecd 58	30	
				31	a 155

Mean, 24 days=93.5.

October 17. Middle large bright chromospheric eruption at 9h 43m to 9h 59m U. T., W.

a= Passage of an average-sized group through the central meridian.

b= Passage of a large group or spot through the central meridian.

c= New formation of a group developing into a middle-sized or large center of activity; E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.

d= Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE in charge]

By B. FRANCIS DASHIELL

During October 1938 a total of 523 aerological observations were made by airplane and radiosonde at 18 points in the United States. The mean free-air data based on these observations are given in tables 1 and 1a. They include the basic meteorological elements of pressure, temperature, and relative humidity, recorded at certain geometric heights. At four stations a maximum height of 21 kilometers was reached during 31 radiosonde observations, while all of the 309 observations listed in table 1a reached a height of 16 kilometers.

The "means" are omitted whenever less than 15 observations are made at the surface and less than 5 at a standard height, but 15 observations are required for those levels that come within the upper and lower limits of the

monthly vertical range of the tropopause. A brief description of the methods used for computing these means will be found under "Aerological Observations" in the January 1938 issue of the MONTHLY WEATHER REVIEW.

The month of October was abnormally warm, as shown by chart 1. The mean surface temperatures (°F.) were above normal throughout the entire United States, with only minor exceptions along the south Atlantic coast, and in Florida and portions of California. East of the Mississippi River and west of the Rocky Mountains, the departures of mean surface temperature above the normal were moderate, but in the central States and upper Missouri valley the mean temperatures were in excess by as much as 10° F. above the normal. These positive

departures in October showed a continuance of the tendency existing throughout the summer and fall months of 1938 for the surface temperature to range considerably above the normal.

Mean free-air temperatures ($^{\circ}\text{C}.$) recorded *above* the surface over the United States during October at all stations were seasonally lower than those noted in the preceding month of September, except over Sault Ste. Marie, Mich., at 3 kilometers. The highest mean temperatures were confined generally to the southern half of the country, but a warm area pushed northward as far as Omaha, Nebr. The highest October means for the country, as recorded at each level, were noted over Pensacola, Fla. ($18.2^{\circ}\text{C}.$); Oklahoma City, Okla. ($18.3^{\circ}\text{C}.$); El Paso, Tex. ($18.3^{\circ}\text{C}.$, $15.4^{\circ}\text{C}.$, $11.9^{\circ}\text{C}.$, and $8.1^{\circ}\text{C}.$); and over Pensacola, Fla. ($0.2^{\circ}\text{C}.$ and $-5.8^{\circ}\text{C}.$); at 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. The lowest mean temperatures of $6.8^{\circ}\text{C}.$, $6.0^{\circ}\text{C}.$, $5.2^{\circ}\text{C}.$, $3.9^{\circ}\text{C}.$, $1.9^{\circ}\text{C}.$, $-6.0^{\circ}\text{C}.$, and $-12.4^{\circ}\text{C}.$, occurred over Sault Ste. Marie, Mich., at 0.5, 1, 1.5, 2, 2.5, 4, and 5 kilometers, respectively, while the lowest at 3 kilometers ($-0.1^{\circ}\text{C}.$) was reported over Seattle, Wash.

Mean temperatures were decidedly lower during the current month at all levels over Seattle and Spokane, Wash., than those recorded in September when the same two stations reported exceptionally warm means at all levels. Over Spokane, Wash., the mean temperatures in October were lower than in September by $10.0^{\circ}\text{C}.$, $9.5^{\circ}\text{C}.$, $8.5^{\circ}\text{C}.$, $7.2^{\circ}\text{C}.$, $6.0^{\circ}\text{C}.$, $4.3^{\circ}\text{C}.$, and $3.4^{\circ}\text{C}.$, at 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. However, over Sault Ste. Marie, Mich., Chicago, Ill., Nashville, Tenn., and Omaha, Nebr., the mean temperatures for October at each level were only slightly lower than those recorded in the preceding month of September.

In the high altitudes above 5 kilometers, where records were obtained only by radiosonde, the lowest mean temperature for the United States was $-65.2^{\circ}\text{C}.$, over Oklahoma City, Okla., at 17 kilometers. Slightly higher mean minimum temperatures ($-60.6^{\circ}\text{C}.$ and $-62.4^{\circ}\text{C}.$) were recorded farther north over Sault Ste. Marie, Mich., and Fargo, N. Dak. All of the lowest mean temperatures for all stations were recorded along the 17-kilometer level as was also the case during the preceding month of September. A gradual increase in the mean temperature occurred upward above 17 kilometers, to as much as $-60.4^{\circ}\text{C}.$ over Oklahoma City, Okla., at 21 kilometers. This was the lowest recorded at the highest altitude reached in October. However, temperatures for the current month were slightly higher in the high altitudes than those recorded during September at corresponding levels.

Isobaric charts prepared from the mean pressure data given in tables 1 and 1a, showed that during October a statistical low pressure area existed in the lower levels over Fargo, N. Dak. In the higher levels this area extended east and west over the entire northern tier of States, but was centered over Sault Ste. Marie, Mich. Pressure, however, in the higher altitudes reached by radiosondes, continued lower over Fargo, N. Dak., as well as Sault Ste. Marie, Mich. Pressure was relatively low over the far Northwest, but it was high over the southern States at all levels with the center apparently over Pensacola, Fla. Mean pressures recorded over the country in October showed little difference from those noted during September, but they were slightly lower over the South in the upper levels, and decidedly lower over Fargo, N. Dak., at all levels.

High relative humidities prevailed during October over most of the Far West, the Pacific coast, and the Northeast,

particularly over Spokane, Wash., and Sault Ste. Marie, Mich., at all levels. This distribution coincided closely with those sections of the United States that showed high percentages of normal precipitation for October, but differed from that condition which existed in the previous month of September when high humidities were found over the eastern half of the country. The highest mean humidity for the United States was recorded over Sault Ste. Marie, Mich., at all levels. It diminished steadily from 90 percent at the surface to 56 percent at 5 kilometers, and 47 percent at 9 kilometers. El Paso, Tex., reported the lowest humidity recorded in the lower levels (39 percent), but this was increased to 60 percent at 4 kilometers. Over Norfolk, Va., the lowest humidity reported at all levels above 2 kilometers (32 percent at 4 kilometers) was noted. This situation held generally over most of the rest of the South and Southeast. But at Omaha, Nebr., while mean relative humidities were comparatively high at all levels, that State reported the smallest amount of precipitation of any during October (11 percent of normal).

Resultant winds in the free atmosphere, based on pilot-balloon observations made near 5 a. m. (75th meridian time), are shown in table 2. The resultant wind directions remained much closer to their normals during the month of October than in the preceding month of September when unusually wide divergences were noted. However, there were several outstanding departures in resultant velocities from normal observed in October, but these were mostly less than normal and confined generally to the 3- and 4-kilometer levels.

The outstanding departures or differences between the October resultant directions and their normals in each level over the United States were: 163° at Medford, Oreg. (when the October direction is rotated in a clockwise direction away from its normal); 119° , 87° , 82° , 96° , and 86° (when rotated counterclockwise) over Oakland, Calif.; 162° (counterclockwise) and 153° (clockwise) over Key West, Fla.; and 75° (counterclockwise) over Spokane, Wash.; at the surface, 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively.

The greatest departures of the resultant directions from normal at all levels were noted over Oakland, Calif.; Key West, Fla.; Medford, Oreg.; Atlanta, Ga.; San Diego, Calif.; and Nashville, Tenn. Over Oakland, Calif., the October resultant directions were 158° , 235° , 278° , 270° , 244° , 246° , 251° , 305° , and 332° , as compared to the established normals of 156° , 354° , 5° , 352° , 340° , 332° , 294° , 272° , and 313° , at the surface, and 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. As previously recorded for several months in 1938, the stations at St. Louis, Mo.; Chicago, Ill.; and Oklahoma City, Okla., again showed the least departures from the October resultant directions and their normals at all levels.

Farther north, at Medford, Oreg., the greatest departures occurred at the surface and at 0.5 kilometer, where the differences were 163° and 113° , when rotated in a clockwise direction. Above these levels the differences were much less, and the monthly resultants departed in an opposite direction with a counterclockwise rotation away from normal. In the South, over Atlanta, Ga.; Nashville, Tenn.; and Pensacola, Fla., decided variations from normal were noted in the upper levels. Above 1.5 kilometers they departed widely from normal in a clockwise direction so that the winds were northerly. Atlanta, Ga.; showed outstanding departures at all levels. These differences were: 10° , 25° , 26° , 62° , 45° , 53° , 67° , 64° , and 68° , departing in a clockwise direction northward from normal,

at the surface, and 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively.

The distribution of resultant wind directions over the United States at all levels during October showed that, above the surface, the winds were almost generally from a westerly direction. At 1.5 kilometers 45 percent of the winds fell in the northwest quadrant, 32 percent in the southwest, 14 percent in the southeast, and 9 percent in the east. Of all the winds having westerly components those from the northwest quadrant predominated slightly at all levels up to 4 kilometers. At 5 kilometers, however, 50 percent of the winds were southwesterly, 37 percent northwesterly, and 13 percent northeasterly. A small percentage of the directions fell in the northeast quadrant at all of the levels from 0.5 to 5 kilometers.

Over San Diego, Calif., Seattle, Wash., Albuquerque, N. Mex., and Cheyenne, Wyo., the current wind directions departed from normal by turning in a counterclockwise rotation at all levels, while over Atlanta, Ga. (as explained), Boston, Mass., and Brooklyn, N. Y., the winds departed from normal by rotating in clockwise directions. The departures in direction at each level over all pilot-balloon stations were nearly equally divided—56 percent having counterclockwise rotations away from their normals, and the average station departure from normal for each level showed there was a steady increase in the departure differences with altitude. These average differences (all stations) between the current resultant directions and the normals for each level were: 26°, 38°, 24°, 25°, 29°, 32°, 35°, 44°, and 47°, at the surface, and at 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. The 2-kilometer level showed the most consistent departure in direction, for 63 percent of all stations recorded departures that rotated counterclockwise from their normals.

Resultant wind velocities during October were less than normal at Boston, Mass., by negative differences of 0.3, 2.3, 3.8, 3.2, 4.0, 3.7, 2.7, and 5.6 meters per second, at the surface, and at 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. This station showed more negative departures at all consecutive levels than any other station in the country. Billings, Mont., Chicago, Ill., Detroit, Mich., Spokane, Wash., and St. Louis, Mo., reported smaller negative departures at all levels. No station showed positive (or greater than normal) velocity departures at all levels, but at Pensacola, Fla., Salt Lake City, Utah, and San Diego, Calif., large positive departure differences were recorded at most of the levels. In this respect, Pensacola, Fla., indicated the greatest positive differences for the country of 1.1, 3.0, 3.4, 2.7, 0.8, and 1.4 meters per second, at 0.5, 1, 1.5, 2, 2.5, and 4 kilometers, respectively. Light velocities, as well as slight departures from the resultant velocity normals, occurred at Oakland, Calif., Fargo, N. Dak., Nashville, Tenn., Key West, Fla., and Atlanta, Ga. Several of these stations showed, as a result, outstanding resultant direction departures from normal.

Maximum wind velocities for October, as shown in table 3, occurred at a number of stations over the United States. Winds having a speed of 50 meters per second or more (114 miles per hour or more) were reported from Las Vegas, Nev., Greensboro, N. C., Evansville, Ind., Billings, Mont., Denver, Colo., and Albuquerque, N. Mex., at different levels. The highest velocity reported was 78.0 m. p. s. (174 miles per hour) from the SW., over Denver, Colo., in the 17th, at 8 kilometers. The greatest velocity recorded nearest the surface was 34.8 m. p. s. over Medford, Oreg., at 0.8 kilometer, and that at the greatest altitude reached was 59.2 m. p. s. over Albuquerque, N. Mex., at 14 kilometers.

TABLE 1.—Mean free-air barometric pressures (*P*) in mb., temperatures (*T*) in °C., and relative humidities (*R. H.*) in percent obtained by air planes during October 1938

Stations and elevations in meters above sea level	Altitude (meters) m. s. l.																											
	Surface			500			1,000			1,500			2,000			2,500			3,000			4,000			5,000			
	Num- ber of obs.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.
Billings, Mont. (1,090 m).....	29	893	8.8	64	---	---	---	---	---	---	850	11.1	53	900	8.8	52	753	5.9	53	708	2.6	51	625	-3.2	55	550	-9.8	52
Cheyenne, Wyo. (1,873 m).....	31	814	5.7	64	---	---	---	---	---	---	---	---	---	802	9.0	54	754	8.6	46	710	5.3	44	627	-1.7	48	552	-9.2	50
Chicago, Ill. (187 m).....	31	996	10.1	78	960	13.5	65	905	12.1	62	852	10.6	56	802	8.6	52	756	6.0	50	710	3.0	49	626	-3.8	50	551	-10.5	47
Coco Solo, C. Z. ¹ (15 m).....	29	1,009	24.5	93	954	23.2	83	902	20.6	84	851	18.0	82	802	15.4	82	756	12.9	80	712	10.5	75	631	4.9	75	558	-0.7	74
El Paso, Tex. (1,193 m).....	31	883	14.2	50	---	---	---	---	---	---	852	18.3	39	803	15.4	40	757	11.9	44	713	8.1	47	631	0.0	60	555	-6.3	51
Lakehurst, N. J. ¹ (39 m).....	27	1,014	9.6	88	960	12.2	64	904	9.5	57	851	6.8	58	801	5.2	47	752	2.8	41	707	0.2	39	624	-6.0	37	---	---	---
Norfolk, Va. ¹ (10 m).....	17	1,020	12.5	84	962	13.4	63	906	10.5	57	854	9.2	51	804	7.8	43	757	5.9	35	712	3.5	33	628	-2.3	32	553	-9.2	31
Pearl Harbor, T. H. ¹ (6 m).....	31	1,015	22.8	82	959	22.5	73	905	19.5	77	854	17.0	74	805	15.1	66	758	13.7	52	715	11.8	47	634	7.8	31	561	3.7	24
Pensacola, Fla. ¹ (13 m).....	31	1,018	14.9	91	961	18.2	65	907	15.6	62	855	13.0	60	805	10.5	54	758	8.1	50	713	5.4	47	631	0.2	41	556	-5.8	34
St. Thomas, V. I. ¹ (8 m).....	31	1,014	27.6	78	959	24.2	88	903	21.5	83	853	18.8	79	806	16.2	78	769	14.0	71	717	11.4	65	635	5.9	58	561	0.1	50
Salt Lake City, Utah (1,288 m).....	31	872	8.6	70	---	---	---	---	---	---	850	12.1	54	801	9.9	51	754	6.9	51	709	3.5	53	628	-2.9	55	551	-9.0	54
San Diego, Calif. ¹ (10 m).....	31	1,015	14.1	88	958	15.2	80	903	15.3	68	851	13.1	61	802	10.7	56	754	8.6	53	710	5.5	48	628	-0.2	43	553	-7.6	41
Seattle, Wash. ¹ (10 m).....	19	1,017	12.2	74	960	12.1	62	901	9.9	56	851	7.7	48	800	5.1	44	752	2.3	43	707	-0.4	40	---	---	---	---	---	---
Spokane, Wash. (597 m).....	31	948	7.4	84	---	---	---	903	9.6	69	850	7.7	67	800	5.0	66	752	2.4	64	706	-0.1	60	623	-4.9	52	548	-10.3	50

¹ Navy.

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5-standard-level observations.

TABLE 1a.—Mean free-air barometric pressures (*P*) in mb., temperatures (*T*) in °C., and relative humidities (*R. H.*) in percent obtained by radiosonde during October 1938

Altitude (meters) m. s. l.	Stations and elevations in meters above sea level																											
	Fargo, N. Dak. (274 m)				Nashville, Tenn. (180 m)				Oakland, Calif. (2 m)				Oklahoma City, Okla. (391 m)				Omaha, Nebr. (300 m)				Sault Ste. Marie, Mich. (221 m)				Washington, D. C. (13 m) ¹			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	31	982	7.0	73	31	998	11.0	80	30	1,016	12.7	84	31	972	14.2	61	31	982	11.8	71	31	992	6.2	90	29	1,019	10.0	88
500	31	956	10.4	69	31	962	15.9	60	30	958	13.9	73	31	930	16.6	58	31	959	14.6	61	31	959	6.8	85	29	961	10.4	73
1,000	31	901	10.5	61	31	906	14.4	54	30	903	12.8	62	31	903	18.3	50	31	905	15.6	52	31	902	6.0	79	29	905	8.3	70
1,500	31	848	8.8	56	31	854	11.7	52	30	851	10.8	56	31	851	15.6	49	31	853	13.1	50	31	819	5.2	73	29	852	6.1	67
2,000	31	798	7.0	51	31	804	9.6	47	30	801	8.0	53	31	805	12.2	50	31	803	10.3	50	31	798	3.9	66	29	801	4.8	59
2,500	31	751	4.6	49	31	757	7.1	45	30	754	5.4	48	31	758	8.7	51	31	756	7.5	49	31	750	1.9	65	29	753	3.3	52
3,000	31	706	1.7	49	31	712	4.5	43	30	703	2.7	46	31	713	5.4	48	30	711	4.4	49	31	705	0.6	62	29	708	0.9	50
4,000	31	622	-4.6	50	31	629	-1.2	41	30	625	-3.0	43	31	630	-0.7	43	30	628	-2.8	51	31	622	-6.0	56	29	624	-4.5	44
5,000	31	548	-11.4	52	31	555	-7.2	40	30	551	-9.3	40	31	555	-6.8	39	30	553	-9.0	47	31	540	-12.4	56	29	548	-10.8	41
6,000	31	480	-18.4	51	31	487	-14.0	36	30	483	-15.9	39	31	488	-14.0	36	30	485	-15.5	45	31	478	-18.8	51	29	480	-17.6	38
7,000	31	419	-25.4	47	31	426	-21.0	36	29	423	-22.8	41	30	427	-21.3	34	30	424	-22.5	43	31	418	-25.6	48	29	420	-24.3	36
8,000	31	364	-32.7	44	30	371	-28.0	36	28	368	-29.4	39	30	372	-28.3	34	30	370	-29.8	43	31	364	-33.1	48	28	366	-30.8	34
9,000	31	315	-39.9	41	30	322	-35.3	36	27	319	-36.5	39	30	323	-35.5	33	30	320	-36.6	43	30	315	-39.7	47	27	317	-37.1	31
10,000	31	272	-46.8	38	29	279	-42.0	32	26	276	-43.2	32	30	279	-42.6	32	30	277	-43.2	32	29	273	-45.9	32	26	276	-48.5	25
11,000	29	233	-53.0	35	25	210	-48.0	28	25	237	-49.2	28	29	240	-48.7	28	30	238	-49.7	28	29	231	-51.5	28	26	232	-50.2	25
12,000	28	199	-57.6	33	22	206	-53.1	24	25	203	-53.3	28	28	206	-54.1	28	30	204	-54.2	28	29	200	-55.3	32	25	174	-55.8	22
13,000	26	170	-60.3	33	22	176	-58.1	24	24	174	-55.8	28	27	176	-57.8	28	30	174	-57.5	28	29	171	-57.7	32	23	148	-58.4	18
14,000	25	141	-60.7	33	21	150	-58.3	24	24	148	-58.1	28	27	150	-60.7	28	30	149	-60.0	28	29	146	-58.9	32	23	126	-60.3	14
15,000	24	123	-61.4	33	21	128	-60.5	22	22	126	-60.1	28	27	127	-63.3	28	30	126	-62.0	28	29	124	-59.7	32	23	107	-60.8	10
16,000	23	105	-62.3	33	22	109	-61.8	20	20	107	-61.1	28	25	108	-64.7	28	27	107	-62.1	28	29	106	-60.2	32	23	88	-60.8	8
17,000	23	88	-62.4	33	22	93	-62.3	19	19	91	-61.0	28	22	92	-65.2	28	27	91	-62.4	28	29	90	-60.6	32	23	77	-61.0	7
18,000	22	75	-61.9	33	19	79	-61.2	16	16	77	-60.4	28	21	77	-64.2	28	17	78	-61.4	28	21	77	-60.5	32	16	66	-60.1	6
19,000	14	64	-61.3	33	15	67	-60.1	12	12	65	-59.4	28	19	67	-62.9	28	9	66	-60.5	28	16	66	-60.1	32	12	56	-60.0	5
20,000	10	54	-60.3	33	13	57	-59.0	11	11	56	-58.6	28	14	57	-61.6	28	8	56	-58.9	28	12	56	-60.0	32	10	49	-57.9	5
21,000					9	49	-57.9		5	47	-57.8		10	48	-60.4						7	48	-59.6					

¹ Navy.

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels also the humidity data is not used in daily observations when the temperature is below -40° C.

TABLE 2.—Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during October 1938

[Wind from N=360°, E=90°, etc.]

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (302 m)		Billings, Mont. (1,095 m)		Boston, Mass. (15 m)		Brooklyn, N. Y. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (153 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (274 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Surface	2	1.7	15	1.4	275	2.1	336	1.5	345	2.2	274	3.5	217	1.3	53	0.4	237	1.4	170	0.8	2	1.4	50	2.5	325	0.4
500			55	2.4			353	1.6	9	4.8			235	4.9	213	1.3	251	4.1	230	1.3	113	1.4	59	5.2	315	0.7
1,000			56	3.5			319	1.8	356	5.0			258	5.1	270	3.3	255	5.7	282	2.8	89	2.3	91	3.8	154	1.5
1,500			15	2.2	256	3.1	307	4.0	313	5.0			270	6.3	296	4.0	273	5.8	279	5.4	66	2.7	122	1.3	175	2.7
2,000	171	2.2	347	2.9	263	4.4	312	4.3	315	4.9	269	5.4	274	6.4	308	4.4	296	5.3	270	8.0	63	2.5	153	0.7	190	4.0
2,500	214	5.0	352	2.7	280	5.2	306	5.7	323	5.5	269	6.7	282	6.1	314	3.8	290	6.7	276	8.8	44	3.3	190	0.4	201	4.2
3,000	223	5.6	7	3.9	277	5.7	307	7.7	324	4.8	268	4.8	293	6.6	339	4.1	298	6.4	296	10.7	53	3.3	300	0.6	231	3.0
4,000	322	6.8	3	4.1	248	2.2	351	5.5	347	7.3	266	5.1			328	6.4	308	6.8	305	7.6	17	3.0	118	0.8	254	2.5
5,000	244	6.5	358	2.4							216	8.9									349	3.9				

Altitude (meters) m. s. l.	Nashville, Tenn. (194 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Har- bor, Terri- tory of Hawaii ¹ (68 m)		Pensacola, Fla. ¹ (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,294 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washing- ton, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Surface	224	0.4	158	1.0	167	2.9	166	1.1	47	2.5	34	4.0	247	0.8	162	3.5	25	0.8	98	1.0	145	1.3	154	0.6	320	1.1
500	166	2.1	235	1.3	179	5.2	205	4.3	71	5.4	65	5.7	217	3.5			330	1.7	185	1.4	175	3.0			346	3.6
1,000	278	1.6	278	1.3	199	8.0	240	8.3	80	5.7	55	4.7	267	3.4			316	1.8	271	4.2	194	5.0	188	1.3	350	4.0
1,500	312	2.8	270	2.7	218	4.7	245	8.4	83	4.4	43	4.5	278	4.6	166	5.5	278	1.0	277	6.3	205	5.2	226	1.8	333	5.3
2,000	334	4.0	244	1.8	243	3.4	261	7.9	85	4.1	30	4.4	283	4.8	183	5.2	202	2.2	283	8.9	202	4.5	233	1.9	324	5.5
2,500	336	4.0	246	2.1	264	3.0	272	6.8	76	2.4	41	3.8	287	5.6	205	4.4	195	3.0	302	7.3	195	5.3	229	3.0	318	5.5
3,000	337	3.4	251	1.8	280	2.7	283	7.0	73	2.0	7	2.7	290	6.4	216	4.2	207	2.9	303	8.0			221	3.2	310	6.2
4,000	353	4.3	305	2.8	319	3.6	299	6.5	26	2.3	316	4.9	302	4.1	210	5.2	189	4.8					250	3.5	341	7.5
5,000	18	4.0	332	4.0					9	3.6					274	3.8	214	7.6					199	3.2		

¹ Navy stations.

TABLE 3.—Maximum free air wind velocities (m. p. s.), for different sections of the United States, based on pilot balloon observations during October 1938

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station
Northeast ¹	39.2	SW	2,140	26	Cleveland, Ohio	39.0	SW	3,700	19	Cleveland, Ohio	39.0	WNW	9,880	15	Cleveland, Ohio
East-Central ²	30.2	WSW	2,230	26	Cincinnati, Ohio	31.0	W	3,490	26	Cincinnati, Ohio	50.0	SW	6,840	24	Greensboro, N. C.
Southeast ³	28.2	WNW	2,500	27	Spartanburg, S. C.	34.6	SW	5,000	24	Charleston, S. C.	46.0	SW	6,960	24	Charleston, S. C.
North-Central ⁴	29.1	NNE	1,000	14	Huron, S. Dak.	41.8	NNW	4,930	26	Fargo, N. Dak.	43.0	W	9,130	13	Fargo, N. Dak.
Central ⁵	35.4	W	2,390	5	Evansville, Ind.	36.8	NNW	3,230	27	Moline, Ill.	54.0	WNW	11,930	25	Evansville, Ind.
South-Central ⁶	29.2	S	1,530	17	Amarillo, Tex.	26.6	NW	3,910	23	Oklahoma City, Okla.	45.0	W	12,330	21	Oklahoma City, Okla.
Northwest ⁷	34.8	SE	820	28	Medford, Oreg.	35.0	SSW	2,880	28	Pendleton, Oreg.	59.2	NE	9,380	8	Billings, Mont.
West-Central ⁸	35.2	S	2,100	14	Salt Lake City, Utah	34.4	SSW	3,000	15	Salt Lake City, Utah	78.0	SW	7,960	17	Denver, Colo.
Southwest ⁹	27.6	SSW	2,500	15	Las Vegas, Nev.	50.0	SSW	3,540	15	Las Vegas, Nev.	59.2	WSW	14,040	18	Albuquerque, N. Mex.

¹ Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.

² Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.

³ South Carolina, Georgia, Florida, and Alabama.

⁴ Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.

⁵ Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.

⁶ Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.

⁷ Montana, Idaho, Washington, and Oregon.

⁸ Wyoming, Colorado, Utah, northern Nevada, and northern California.

⁹ Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By BENNETT SWENSON

No floods occurred during the month of October 1938 with the exception of floods in the upper Mississippi Basin and in the lower Rio Grande which were a continuation of overflows that began in September. The flood in the upper Mississippi will be discussed below. The overflow in the Rio Grande was limited to the extreme lower reach of the river. Flood stage was exceeded at Mercedes and Brownsville, Tex., from September 29 to October 3 and crested on October 1 at a stage of 22.0 feet at the former station and 18.6 feet at the latter. The principal damage in this flood was caused by a break in the main levee, on the American side of the river, about 2 or 3 miles above Brownsville, Tex., resulting in inundation of approximately 1,200 acres of land. The total damage has been estimated at \$2,500.

The upper Mississippi flood resulted from heavy rains over southern Minnesota, southern Wisconsin, northern Illinois, and central and northern Iowa. The flood was largely a tributary flood, with the Chippewa, Black, Wisconsin, Zumbro, and Whitewater Rivers particularly, experiencing unusually severe floods. The heavy rains began about September 5 and continued until September 14, and occurred again from the 17th to the 19th, but the rains of the latter period were not generally as intense and did not have a great effect on the high water except to prolong it somewhat. Figure 1 shows the distribution of precipitation from September 5 to 14. The data used in the preparation of the isohyets may be found in *Climatological Data*.

A meteorological analysis of the storm shows that the rainfall was caused primarily by a strong influx of moist tropical air from the south and southwest overrunning a wedge of cold polar air to the north and northeast over the extreme upper portion of the Mississippi Valley. This condition persisted almost entirely from September 5 to 14.

The front at the surface lay in a general east-west direction approximately over the southern boundaries of Minnesota and Wisconsin and remained almost stationary from the 5th to the 12th. A series of active waves moving along this front produced frequent rains during this

period. On the 12th a mass of polar air moved in from the northwest and the front was displaced slightly to the southeast, resulting in clearing weather temporarily. However, on the morning of the 13th another wave had advanced northeastward to southwestern Iowa accompanied by moderately heavy precipitation. This disturbance moved slowly eastward from that point followed by a large mass of dry polar air which dominated the upper Mississippi region by the evening of September 14.

The stream of tropical air which invaded the upper Mississippi Valley from September 5 to 14 was maintained by a large anticyclone situated over extreme eastern United States and extending to high elevations. At 14,000 feet the center was located approximately over western Tennessee and dominated most of the eastern half of the country. The persistence of this anticyclone prevented any marked invasion of polar air except in the extreme upper portion of the Mississippi Basin until the 14th, when the anticyclone weakened considerably at high levels and was displaced to the southward and southeastward. At the same time a low at high levels moved eastward over the Lake region and brought in cold air from the northwest over most of the Mississippi Valley.

The flood was unusual in that floods rarely occur at that season of the year in the upper Mississippi Basin, the flood season extending usually from March to June. Table 1 presents crest stages at various points on the principal streams together with comparative data.

The following reports have been submitted by the officials in charge at the various river district offices in the upper Mississippi Valley:

LA CROSSE, WIS., RIVER DISTRICT

Whitewater and Zumbro Rivers in Minnesota.—An intense local flood of short duration occurred in the Whitewater River area from September 6th to 9th. Two storms of over 2 inches of rain produced disastrous floods in this valley which caused considerable loss to bridges, highways, crops, and a few buildings. Flood damage was greatest at Weaver, Minn., also considerable damage occurred at Elba and Beaver, Minn.; the latter town was isolated and had the highest stage recorded in years. Rains of great in-